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THE VAMPYROMORPHA OF THE DISCOVERY EXPEDITIONS

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THE VAMPYROMORPHA OF THE DISCOVERY EXPEDITIONS

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(Text-figs. 1-4)

INTRODUCTION

DURING the years 1927 to 1937 the ships of the Discovery Committee captured nine specimens of the octopod, *Vampyroteuthis infernalis* Chun. This material contributes towards our knowledge of vampyromorph morphology, throws new light on the geographical range of the species, and tends to confirm previous findings with regard to vertical distribution and hydrographical correlations. A survey of previous investigations is contained in the following papers, Pickford (1946, 1949*a*, 1949*b*, 1950).

I am indebted to the National Institute of Oceanography (which has taken over the work of the Discovery Committee) for permission to examine these interesting specimens, and to Dr W. J. Rees for working facilities at the British Museum during the summer of 1951.

MORPHOLOGICAL CHARACTERS

Colour. In four cases the original colour of the specimen has been entered on the label. Specimen No. 99: 'Deep purple'; specimen No. 101: 'General tendency dark almost inky purple. Pale translucent purple where epidermis rubbed off'; specimen No. 102: 'Epidermis very deep inky purple, almost black. Translucent pale purple where skin stripped off'; and specimen No. 103: 'Intense deep purple'.

These observations are unexpected and interesting. The present colour of the external surface is black, as it is in all preserved specimens that are not totally faded as the result of prolonged storage in neutral formalin. The purple colour is evidently due to an unstable pigment that fades in preserving fluids. However, two points are worth noting. The formalin preserved specimens of the Bingham Oceanographic Collection retained a good deal of pink or red colour that could be seen on the suckers, the cirri, and the inside of the mantle where black and brown chromatophores are not present. Unpublished results of histological study show that this pigment is located in the epithelial cells, and not in chromatophores. In preserved specimens it is so faded as to be masked by underlying black or brown chromatophores in the subcutaneous tissues. One must suppose that in life an intense red or purple pigment in the epidermal cells would impart a purple tinge even to an otherwise black background. The writer has only seen freshly captured *Vampyroteuthis* on two occasions, while with the Danish 'Galathea' Deep Sea Expedition in 1951 in the Bay of Bengal. Unfortunately these specimens were badly rubbed and damaged; such colour as remained was black, but this may well have been due to destruction of the epidermis.

A further problem concerns the natural colour of the oral face of the web. The original coloured picture (Thiele, 1914) shows it as brown, and this colour has been repeatedly observed by the writer in formalin preserved specimens whenever they were not completely faded by the addition of borax for neutralization. A red-brown web was observed, for example, in the formalin preserved specimens

of the Bingham Oceanographic Collection, and a check on the Bermuda series (Pickford, 1950) shows that here also the oral face is brown. It was therefore a surprise to find that the oral face of the web is black in the nine Discovery specimens which are preserved in alcohol. Presumably in life it may even have been purple. An exactly similar observation was made on the Indian Ocean specimens taken by the 'Galathea'. Five of the Discovery specimens are from the Atlantic Ocean and we may therefore exclude the possibility of zoogeographical differences.

Table 1. *List of specimens, dates of capture and summary of distribution*

Spec. No.*	Stn	Date	Latitude	Longitude	Ocean basin†
96	269	26. vii. 1927	15° 55' 00" S	10° 35' 00" E	Angola basin
97	287	19. viii. 1927	02° 49' 30" S	09° 25' 30" W	Guinea basin
98	1587	3. v. 1935	06° 05' N	52° 00" E	Somali basin
99	1739	17. iv. 1936	32° 05' 9" S	105° 23' E	Junction of Indo-Australian and South Australian basin
100	1764	6. v. 1936	32° 00' 8" S	36° 26' 7" E	Eastern extension of Agulhas basin in S. Indian ocean
101	2059	30. iv. 1937	09° 11' 4" S	05° 17' 4" W	Between Guinea and Angola basins
102	2061	1. v. 1937	06° 36' S	06° 25' 1" W	Guinea basin
103	2065	4. v. 1937	02° 11' 8" S	06° 55' 7" W	Guinea basin
104	2080	29. x. 1937	10° 12' 7" S	04° 02' W	Between Guinea and Angola basins

* Author's register of known specimens. Nos. 1-77 are listed in the Dana Reports (Pickford, 1946, 1949*a*), Nos. 78-95 in *The Vampyromorpha of the Bermuda Oceanographic Expeditions* (Pickford, 1950).

† Designations of basins from Sverdrup, Johnson & Fleming (1942).

Unpublished histological studies on the pigment cells of *Vampyroteuthis* have shown that the black pigment is in the form of rather large, spherical granules whereas the red-brown pigment is in the form of much smaller and more irregular granules that tend to clump in little aggregations, giving an appearance of reticulation to the chromatophore. Clearly there are physical if not chemical differences between the black and 'brown' chromatophores but it is possible that the latter only assume their brown colour after certain methods of preservation. We cannot escape from the fact that in life, and in alcohol preserved specimens of the Discovery collections, the oral face of the web is black.

Mantle length. The observed mantle length of the specimens is given in Table 2, except for specimen No. 96 which was too badly damaged for measurement. The larva of *Vampyroteuthis* goes through a complicated double metamorphosis in which the posterior or larval fin reaches a length of about 5 mm. and is then resorbed, while an anterior (adult) fin develops in smoothly co-ordinated functional adjustment (Pickford, 1949*a*). The developmental stages are defined in terms of the presence or absence and relative lengths of the two pairs of fins. It has further been shown that each developmental stage is associated with a characteristic range of mantle length. But the mantle length of several of the Discovery specimens appears to be in poor agreement with the developmental fin stage. An attempt has therefore been made to deduce a corrected estimate of mantle length from measurements of the eye diameter and of anterior fin length. The estimates are based on a previous investigation of the relationships between mantle length and other bodily proportions, given in the article cited above. These estimates of corrected mantle length are given in Table 3. It will be seen that, in general, the estimates are in good agreement with actual observation. However, specimen No. 101,

which appears to be badly shrunk, is shown to have had a probable mantle length of 20–21 mm. instead of 14 mm. On the other hand specimen No. 103, in which the subcutaneous gelatinous tissues are clearly abnormally swollen, appears to have had a true mantle length of about 26 mm. as compared with the observed value of 30 mm. In both these animals the corrected values are in better agreement with the fin stage than the observed values. The posterior fin of specimen No. 101 is in poor condition and was certainly longer than the 2.5 mm. recorded in Table 2; we may assume that

Table 2. *Morphological characters*

(Measurements in mm.)

Spec. No.	Sex	Mantle length	Eye diam.	Anterior fin length	Posterior fin length	Stage	Comments
96	♂	?	6.0	15.5*	Not vis.	?4	Left eye gone, mantle everted and badly distorted
97	?	10.5	2.9*	?	c. 2+*	?2	Mantle rubbed, fins poor
98	♂	28	6.0	12	0.6	4	
99	♀	47	16.5*	29*	Resorbed	5	Surface rubbed, right eye damaged
100	?♀	c. 10+	2.4	1.0	3.2	2	Condition very perfect, but mantle sac is everted
101	♀	14+	5.0	5.0	2.5+	?3	Rather shrunk
102	♂	25	6.5*	8.0	4.5	4	Skin rubbed
103	♂	30	c. 8* (through tissues)	14	Minute rudiment	4-5	Gelatinous tissues very swollen; right eye protrudes
104	♂	29	9.5	10.0	Minute rudiment	4-5	Skin rubbed

* Left side in better preservation and measured instead of right.

Table 3. *Estimates of true mantle length*

Spec. No.	Observed ML	Estimated from ED*	Estimated from FaL†
96	?	24.5	27
97	10.5	13	—
98	28	24.5	25.5
99	47	41	54
100	10+	12	14
101	14+	21	20.5
102	25	26	23
103	30	25	26.5
104	29	28	24.5

* The relationship between eye diameter (ED) and mantle length (ML) has been analysed by Pickford (1949*a*, pp. 75–6). The curve for adults was used for specimen No. 99, the curve for all stages was used for the two stage 4–5 specimens (Nos. 103 and 104), and the rest were taken from the curve for larvae.

† The relationships between anterior fin length (FaL) and mantle length has been analysed by Pickford (1949*a*, pp. 51–3). The adult curve was used for specimen No. 99, and the rest were determined from the curve for larvae.

it was at least 60% of the length of the anterior fin. This would place the specimen in stage 3, but even this would be inappropriate to a larva of only 14 mm. mantle length whereas a mantle length of 20–21 mm. is entirely to be expected at this stage. The correction for specimen No. 103 is less striking since transitional specimens in the last stages of metamorphosis (stages 4–5) may range from 25 to 39 mm. in mantle length.

Specimen No. 96 is too badly damaged for measurement but estimates from the eye diameter and from anterior fin length indicate a probable mantle length of 24.5–27 mm. There is no trace of a posterior

fin, but, at a mantle length of 25 mm. or more, it is quite possible that the larval fin was in the last stages of resorption. The specimen is tentatively assigned to stage 4.

Specimen No. 97 is also interesting. Anterior fin buds cannot be seen on account of the poor condition of the specimen, yet, at a mantle length of 10.5 mm., it is most improbable that they were not originally present. The eye diameter indicates that the true mantle length may even have been somewhat greater, perhaps as much as 13 mm. The specimen may be assigned to stage 2 with some confidence and it may further be noted that, at the observed mantle length of 10.5 mm., the anterior fin rudiment was probably a triangular bud about 0.3 mm. in length.

Sex and stage. The preceding discussion permits a clear statement regarding developmental stages; sex is determined by the presence or absence of a penis or penis rudiment which is visible even in very young male larvae.

The collection contains one half-grown adult, specimen No. 99, a female. Two specimens, Nos. 103 and 104, are in the final stage of metamorphosis with only minute posterior fin rudiments. Both these specimens are males as also are three more which have been assigned to the last larval stage, viz. specimens No. 96, 98 and 102. As noted above, however, specimen No. 96 may really have already lost its larval fin. The remaining specimens consist of a four-finned larva (stage 3), which is specimen No. 101, a female, and two stage 2 larvae in which the anterior fin is a mere rudiment. One of the latter (specimen No. 97) cannot be sexed on account of poor preservation, nor can the anterior fin bud be seen although, as noted above, it must certainly have been present. Specimen No. 100 is rather well preserved although the mantle is everted, an anterior fin bud is present and the sex is almost certainly female as there is no trace of a penis rudiment.

Primary cirri. Previous investigations have brought to light the interesting possibility that there may be small racial differences between the *Vampyroteuthis* populations of the Atlantic and Indo-Pacific Oceans. Atlantic specimens appear to have one more pair of primary cirri, i.e. cirri that precede the first sucker, on the arms. The difference is not an absolute, all or nothing character, but far more Atlantic specimens have the larger number, and far more Indo-Pacific specimens the smaller.

Table 4. *Number of primary cirri*

Spec. No.	Left				Right				Comments
	1	2	3	4	1	2	3	4	
96	—	—	—	—	—	—	—	—	Condition does not permit an accurate count
97	8	7	6	6	?	7	6	6	—
98	8	7	7	6	8	7	7	6	—
99	8	7	6	5	8	?6-7	6	5	—
100	7	7	6	6	6+	6	6	6	One sucker on first arms, two on rest
101	?7	6	6	6	7	7	6	6	Very difficult to count
102	7	7	6	6	7	6	6	6	—
103	7	6	5	5	7	6	6	5	—
104	?7	—	—	5	7	6	5	4	First pair on R4 represented by a single (ventral) cirrus

The data for the Discovery specimens are tabulated in Table 4 and the results are summarized in Tables 5 and 6. It will be seen that the Discovery specimens contribute nothing towards the hypothesis of racial difference, in fact, for the first time, an Atlantic specimen (No. 104) is found to have a minimum number of four pairs of primary cirri. Nevertheless the overall data are still heavily weighted in favour of the racial hypothesis. The majority of Atlantic specimens have 8 or more pairs of primary cirri on the first or second arms (31 specimens out of 46); the majority of Indo-Pacific

specimens have seven or less (16 out of 26). Similarly on the third and fourth arms the majority of Atlantic specimens have six or more pairs (39 specimens out of 53), whereas the majority of Indo-Pacific specimens have five or less (19 specimens out of 29).

Table 5. *Summary of data on maximum number of pairs of primary cirri, situated normally on the first or second arms*

Group	Maximum number of pairs of primary cirri					Total no. specimens
	6	7	8	9	10	
Atlantic previous records	—	11	19	9*	2	41
'Discovery'	—	4	1	—	—	5
Totals	—	15	20	9*	2	46
Indo-Pacific previous records	1	14	8	—	—	23
'Discovery'	—	1	2	—	—	3
Totals	1	15	10	—	—	26

* Includes one specimen that may have possessed a tenth pair (Pickford, 1949a).

Table 6. *Summary of data on minimum number of pairs of primary cirri, situated normally on the third or fourth arms*

Group	Minimum number of pairs of primary cirri					Total no. specimens
	4	5	6	7	8	
Atlantic previous records*	—	12	28	7	1	48
'Discovery'	1	1	3	—	—	5
Totals	1	13	31	7	1	53
Indo-Pacific previous records	4	17	4	1	—	26
'Discovery'	—	1	2	—	—	3
Totals	4	18	6	1	—	29

* Includes data for the Bermuda series listed but not analysed previously (Pickford, 1950).

GEOGRAPHICAL DISTRIBUTION

The geographical distribution of the Discovery specimens is given in the list of specimens (Table 1) and shown graphically on the map (Fig. 1). Since none is from the Pacific this ocean has been omitted except in so far as its periphery appears on the maps of the Atlantic and Indian Oceans. To complete the picture it may be stated that there are five additional Pacific records, not shown in Fig. 1, which are rather uniformly distributed along a line between Panama and Australia, following the cruise of the 'Dana', 1928–30.

Six of the Discovery specimens are from the Eastern Atlantic, in the vicinity of the Guinea and Angola Basins. This is a region already well known to be populated by *Vampyroteuthis*, and in fact the type specimen came from 1° 56·7' S and 7° 40·6' E in the Gulf of Guinea.

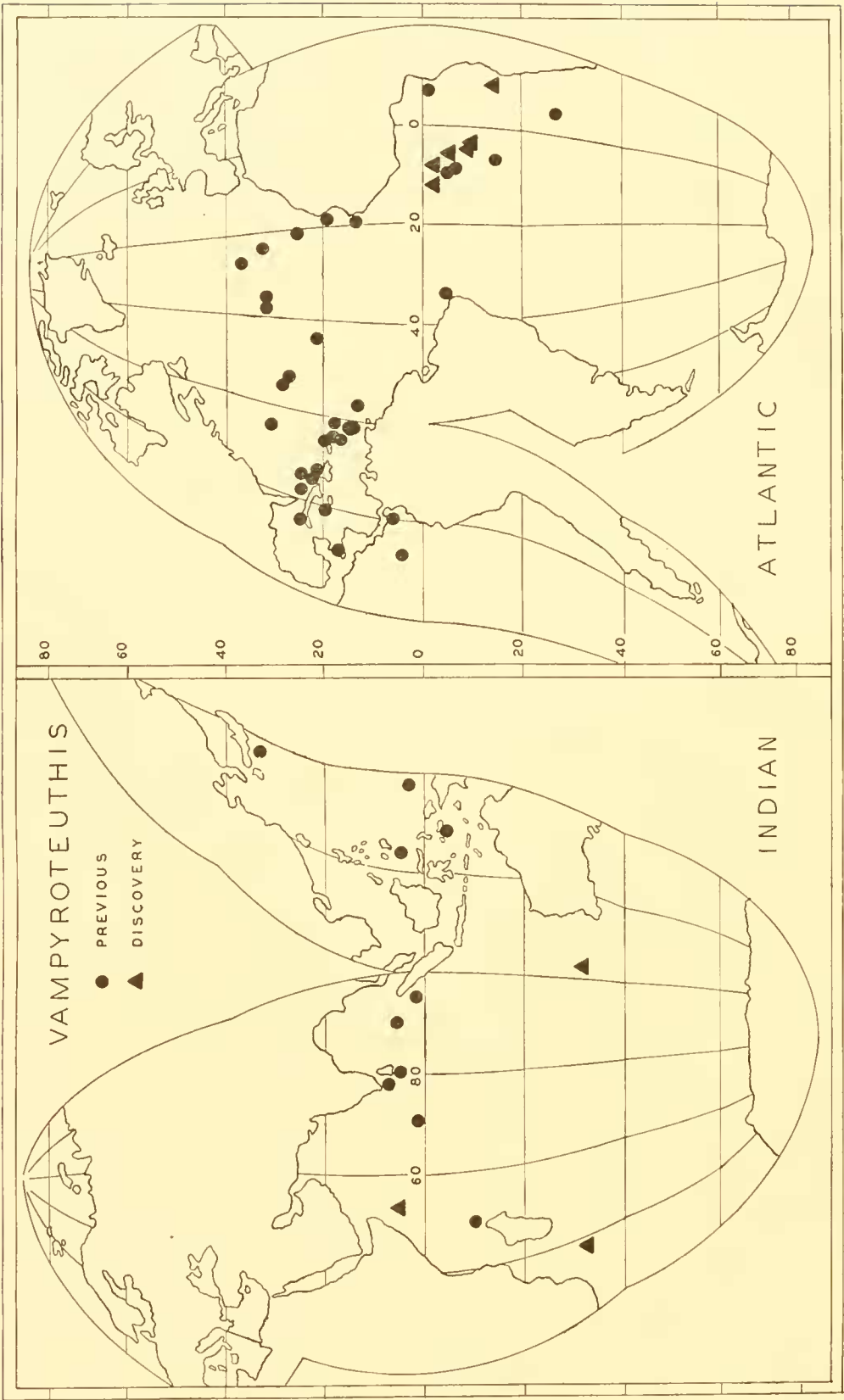


Fig. 1. Maps showing the distribution of *Vampyroteuthis infernalis* in the Indian Ocean (left) and in the Atlantic (right).

The three remaining specimens are more interesting since each one adds a new record from a hitherto unknown region. Specimen No. 98 is from the Somali Basin, near where the Red Sea discharges into the Arabian Sea. Its presence here is entirely to be expected, in view of adjacent records from north of Madagascar and west of Ceylon. Specimen No. 100 from off South Africa in the South Indian Ocean is a most welcome record confirming the hypothesis advanced previously (Pickford, 1946) that the *Vampyroteuthis* populations of the South Atlantic and Indian Oceans must be in free communication with each other by way of suitable water masses passing south of Cape Agulhas.

Finally, specimen No. 99 is of exceptional interest since it is the first record of *Vampyroteuthis* from off Western Australia. The writer has suggested that *Vampyroteuthis* probably occurs in suitable water south of Australia and that the Indo-Pacific populations may be in free communication by this route. The present record appears to favour this hypothesis but more data are required to establish the continuity south of Australia.

VERTICAL DISTRIBUTION

The sounding and depth of capture are listed in Table 7. Six of the nine specimens were taken in nets towed at accurately known depths that were determined with the aid of a depth recorder. Three of these nets were closed before being hauled to the surface, but the other three were hauled open to the surface, either because no closing mechanism was used or because the mechanism failed to operate. Nevertheless it is most probable that the specimens were taken at the depth of towing since the net was fishing at that depth for a much longer time than on the way to the surface. It has been necessary to make this assumption in all previous studies although, in the case of the Dana material it was possible to introduce a correction for specimens captured during lowering and raising of the net. This is not possible for the Discovery records.

Table 7. *Summary of data on net type, sounding and depth of capture*

Spec. No.	Station	Sounding (m.)	Net type*	Depth† (m.)	Depth recorder‡
96	269	—	TYF	600–700 (–o)§	DGB
97	287	—	TYF	800–1000 (–o)	DGB
98	1587	5098	TYF B	1250–800	DGP
99	1739	5400	TYF B	3000–2000 (–o)	DGP
100	1764	2430	N 450 B	1000–0	—
101	2059	4370	N 450 B	1400–0	—
102	2061	4390	N 450 B	1500–0	—
103	2065	4849	N 450 B	1600–1400	DGP
104	2080	5305	TYF B	1750–950	DGP

* TYF = Young fish trawl; B = oblique haul; N 450 = 4.5 m. tow net.

† The symbol (–o) means either that no closing mechanism was used or that 'the net failed to close at some intended intermediate depth and fished all the way to the surface'.

‡ DGB = Depth gauge, Budenberg pattern; DGP = Pressure depth gauge, a modification of the Budenberg pattern.

§ Note on original label 'Ceph. fragments (–o)'.

|| Note on original label 'Caught in upper netting'.

The vertical distribution is in general agreement with previous investigations. The six Atlantic specimens were taken, presumably, in depths ranging from 600 to 1750 m. Forty-three out of 53 previously recorded Atlantic specimens were taken with towlines of 2000–4000 metres of wire (Pickford, 1950), i.e. at depths of 1000–2000 m. Similarly the three Indian Ocean specimens are from 800 to 3000 m., and previous records for the Indian Ocean are all from 1000 to 2000 m. estimated depth.

The only point of interest pertains to the shallowest depth at which the species may occur. In the Atlantic the 'Dana' captured two specimens at St. 1322, one with a towline of 1600 m.w., the other with 1900 m.w. In the Philippines Basin, at St. 3751, she took one specimen with a towline of only 1000 m.w. The 'Pawnee' took one Atlantic specimen with a towline of 1981 m.w. at St. 56, but this is so close to 2000 that it may well be disregarded. The difficulty with all these records is the interpretation. In the middle depths, with towlines of 2000-6000 m.w. it is probable that the approximate depth of capture may be at one-half the length of the towline. With shorter lengths of cable the matter becomes less certain and the 'Dana' considered that in shallower depths, with less than 1000 m.w., a better estimate of fishing depth was at one-third the length of the cable.

Using the deeper estimate we may say that previous records of *Vampyroteuthis* from shallower water have been made at depths of 800-890 m. in the Atlantic Ocean, and 500 m. in the Philippines Basin. If we convert these estimates to depths at one-third the length of the towline they become 533-660 m. and 333 m. respectively. The data for the Discovery specimens would be more decisive, since depth recorders were used, were it not for the fact that several of the nets were hauled to the surface without closing. However, it is certain that specimen No. 96 was not taken below 700 m. and most probable that it was captured at the depth of towing, 600-700 m. Similarly, specimen No. 97 could not have been taken below 1000 m. and was probably taken between 800 and 1000 m. In the case of specimen No. 98 the closing device operated successfully and we can definitely state that this animal was taken between 1250 and 800 m.

As far as the information goes it appears to indicate that previous estimates for shallow water captures should be taken at half the length of the cable and that the species rarely if ever occurs above 500 m.

In regard to proximity to the bottom, it will be noted that all the Discovery specimens were taken in middle depths over deep or very deep water. None could have been taken within even 1000 m. of the bottom.

Table 8. *Summary of hydrographic data*

Spec. No.	Prob. depth capture (m.)	Hydrogr. station*	Hydrographic data			
			Depth (m.)	Temp. (° C.)	Salinity (‰)	Density (σ_t)
96	600-700	265	600	6.88	34.56	27.11
			800	6.74	34.56	27.12
97	800-1000	289	800	6.27	34.50	27.15
			1000	4.68	34.50	27.33
98	1250-800	1588	790	8.69	35.22	27.37
			990	7.53	35.19	27.51
			1490	4.92	35.01	27.72
99	3000-2000	1740	1950	2.48	34.71	27.73
			2430	2.03	34.72	27.77
			2920	1.67	34.72	27.79
103	1600-1400	2062	1380	4.01	34.92	27.74
			1570	3.82	34.97	27.81
104	1750-950	2058†	990	4.06	34.58	27.47
			1190	3.87	34.73	27.61
			1390	3.75	34.85	27.71
			1590	3.55	34.93	27.80

* That nearest to station of capture and at about same date unless otherwise indicated. Data from the Station Lists (*Discovery Reports*, vol. 1, 22 and 24).

† The specimen was taken at Stn 2080 in October 1937, the hydrographic data are for April 1937.

HYDROGRAPHIC CORRELATIONS

The hydrographic data for stations adjacent to the place of capture and at depths corresponding to the probable depth of capture, are summarized in Table 8. Selected mean values used for plotting are given in Table 9. The writer is deeply interested in the distribution of bathypelagic marine organisms in relation to water types and has suggested the use of temperature-salinity charts for the

Table 9. *Selected or interpolated values of temperature and salinity at the most probable mean depth of capture, derived from Table 8 and used in plotting the distribution in relation to water types (Figs. 2, 3 and 4)*

Spec. No.	Selected depth (m.)	Estimated temp. (° C.)	Estimated salinity (‰)
96	700	6.80	34.56
97	900	5.40	34.50
98	990	7.53	35.19
99	2430	2.03	34.72
103	1475	3.90	34.95
104	1290	3.80	34.70

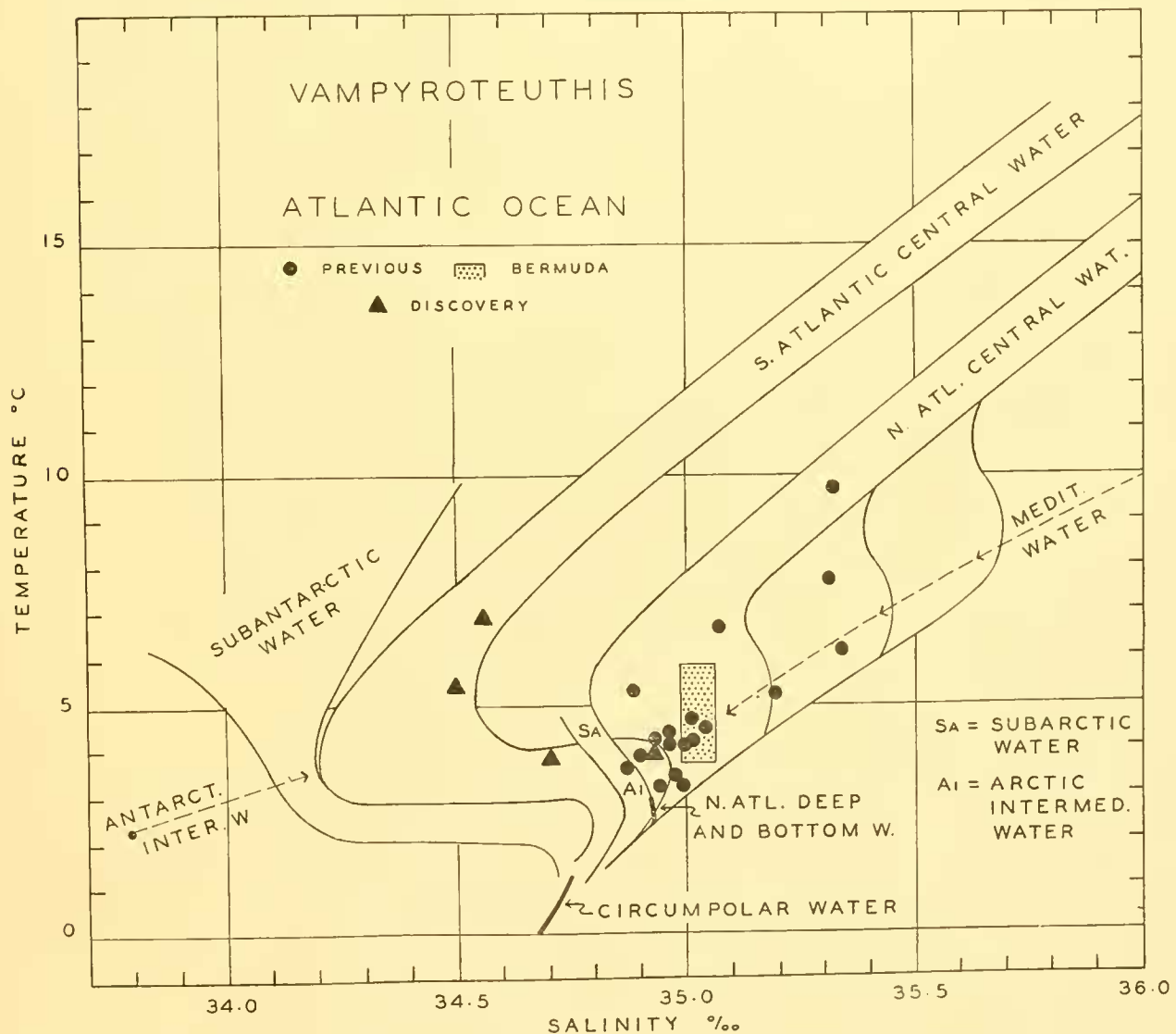


Fig. 2. The distribution of *Vampyroteuthis infernalis* in relation to the water masses of the Atlantic Ocean.

analysis of hydrographic correlations (Pickford, 1946). The distribution of *Vampyroteuthis* in relation to the water masses of the Atlantic and Indian Oceans is shown in Figs. 2 and 3. The names adopted here for the various water masses are those used by Sverdrup, Johnson & Fleming (1942). In the Atlantic the species inhabits the upper layers of the Deep Water and moves upwards into the North Atlantic Central Water. New records made by the 'Discovery' show that it also moves upwards into the South Atlantic Central Water. This was entirely to be expected, but it is satisfactory to have verification.

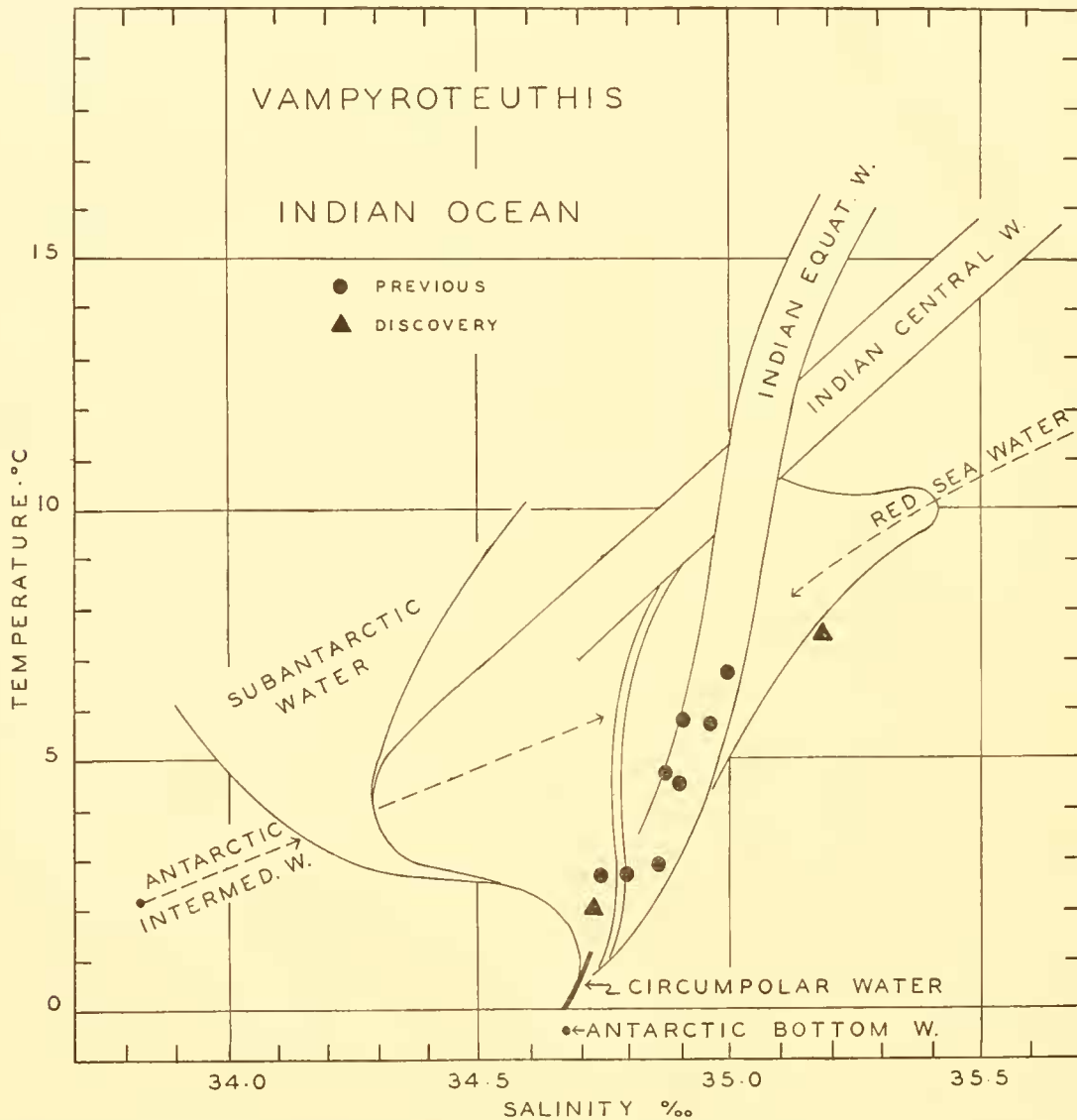


Fig. 3. The distribution of *Vampyroteuthis infernalis* in relation to the water masses of the Indian Ocean.

In the Indian Ocean the few previous records are from the Indian Deep Water and upwards into the Indian Equatorial Water. One of the two Discovery records is from the Deep Water. The other, specimen No. 98 from the Somali Basin, is from a region where Red Sea Water is flowing out to join the Equatorial Water. At the present time there are no records from Indian Central Water.

The distribution of *Vampyroteuthis* in relation to temperature, salinity, and density is further summarized in Fig. 4 in which the new records are indicated in solid black. Empirically the species appears to be restricted to water of salinities between 34.4 and 35.4 ‰, of temperatures between 2 and 10° C., and of densities between σ_t 27.0 and 27.9. Dr E. F. Thompson has suggested that the last

mentioned is the determining factor and that the species is passively caught in a layer of constant density. Nevertheless the animals appear to be strongly stenohaline and are not found in waters of suitable density when the salinity is less than 34.4‰. Yet there are cold waters of low salinity and appropriate density at suitable depths. The upper limits of temperature-salinity tolerance are more readily explainable since in passing them the animal would be led into regions above the oxygen minimum where light penetrates and so into what is well known to be a totally different life zone.

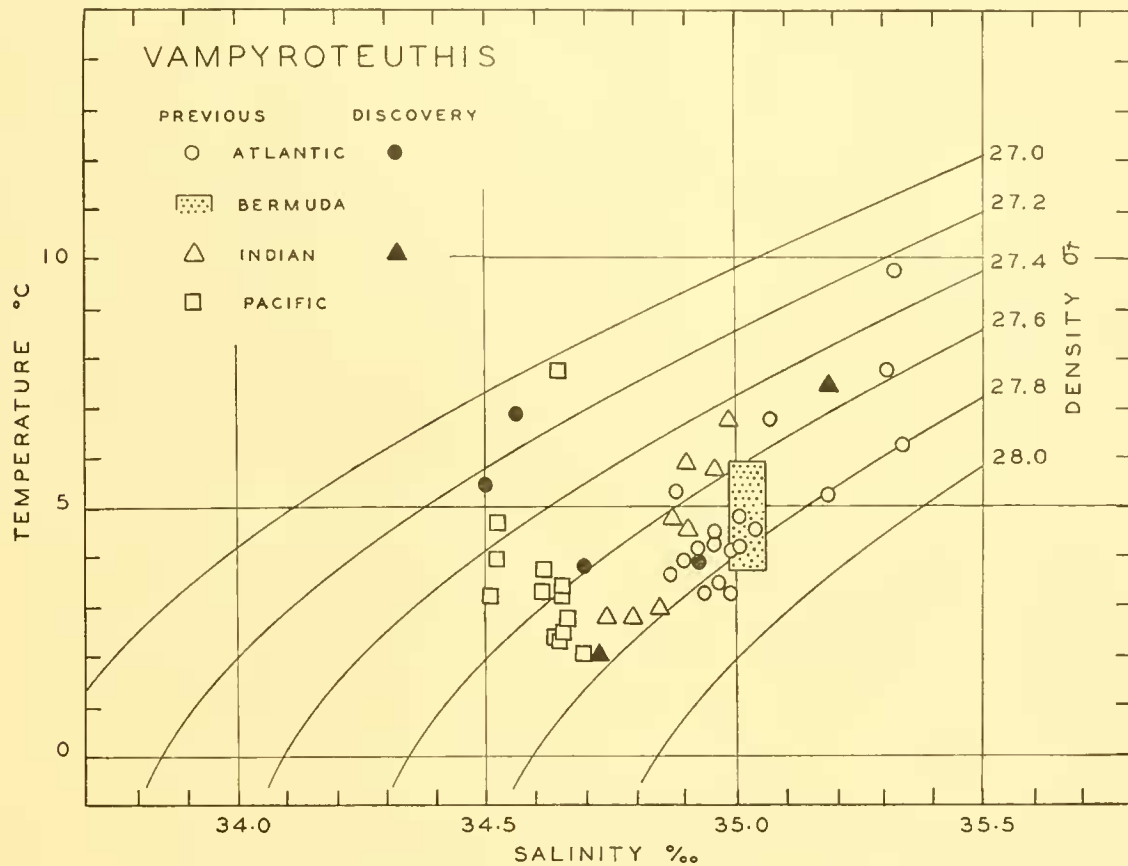


Fig. 4. The distribution of *Vampyroteuthis infernalis* in relation to salinity, temperature and density.

In regard to the individual records, it will be noted that the Discovery specimens from the South Atlantic Central Water fall among the Pacific group, whereas the specimen from the Somali Basin finds itself in water of high salinity and temperature, of a type hitherto known to be inhabited by *Vampyroteuthis* only in the Atlantic. Evidently, within the limits of temperature-salinity tolerance, the geographical region is of no importance.

SUMMARY

1. Nine specimens of *Vampyroteuthis infernalis* Chun were captured by the Discovery Expeditions between the years 1927 and 1937.

2. The colour of the living animal is deep purple rather than jet black. This colour is due to a red or purple pigment in the epidermal cells which fades after preservation. The oral face of the web is black, or perhaps deep purple, not brown as previously described. The latter colour is apparently an artifact of preservation.

3. Eye diameter and anterior fin length are used to adjust the observed mantle length in cases of damage, shrinkage or distortion. Subject to such correction the specimens are found to fall into size

ranges appropriate to their developmental fin stage. There is one immature adult, five metamorphosing larvae (stage 4 or 4-5), and three younger larvae.

4. The number of pairs of primary cirri adds nothing to the hypothesis that there is a racial difference in this respect between the Atlantic and Indo-Pacific populations. Nevertheless the tabulation of known data is still heavily weighted in favour of the view that Atlantic specimens tend to have an additional pair of primary cirri on all arms. One Atlantic specimen with a minimum of only four pairs is recorded.

5. The six Atlantic specimens are from the Guinea and Angola Basins where *Vampyroteuthis* is known to occur. The three Indian Ocean specimens provide a corresponding number of unique records, from the Somali Basin, the eastern extension of the Agulhas Basin and the region of junction of the Indo-Australian and South Australian Basins. The last two records tend to confirm the hypothesis of open communication between the *Vampyroteuthis* populations of the Atlantic, Indian and Pacific Oceans by pathways passing south of South Africa and south of Australia.

6. The vertical distribution of the Discovery specimens, from 600 to 3000 m., is rather accurately known through the use of closing nets and depth-recording gauges. The range corresponds with previous estimates in which depth of capture was taken to be at one-half the length of the cable. The upper limit for the species is probably not less than 500 m.

7. Hydrographical data are available for four Atlantic and two Indian Ocean specimens. Three Atlantic specimens are from South Atlantic Central Water, expected but not hitherto known to be inhabited by *Vampyroteuthis*. The specimen from the Somali Basin is from a region of high salinity and temperature where the Red Sea Water flows out into the Indian Equatorial Water. The two remaining specimens are from Atlantic Deep and Indian Deep Water respectively.

8. The newly recorded specimens are distributed within previously established co-ordinates delimiting the salinity (34.4-35.4‰), temperature (2-10° C.), and density (σ_t 27.0-27.9) tolerances of the species.

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